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GUIDELINES FOR IDENTIFYING AND TREATING BLACKSPOTS

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Guidelines for Identifying and Treating Blackspots

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GUIDELINES FOR IDENTIFYING AND TREATING BLACKSPOTS

1. INTRODUCTION

Road crash is a random phenomenon; however, crashes may not be randomly distributed across road networks. There are locations with a concentration of crashes. In this regard, blackspot management process will help to identify those locations where higher number of crashes having similar nature are occurring as a result of local risk factors. Often the circumstances that are specific for a location are partly responsible for the high number of crashes. Location-specific, infrastructural measures can be implemented to decrease the number of crashes and to put an end to the concentration of crashes at that location. This can be defined as "treating the blackspot sites".

At the same time, it is to be borne in mind that the availability of good and reliable crash data is the core of any blackspot management programme. It is imperative to collect and analyze road crash data for understanding why crashes occur, what could be the local risk factors which lead to the incidence of frequent crashes in a short road section, and what determines the severity of crash. Based on the assessment, we need to arrive at a reliable conclusion on how to prevent them most effectively and efficiently. Thus, blackspot improvement is a crash data-led investigation process to understand the causes of road crashes and then to design and implement matching counter measures.

The occurrence of crashes or black spots are due to various factors like human error, road environment and vehicular condition in addition to engineering factors. Notwithstanding the effectiveness of blackspot improvements, road safety professionals should keep in mind that blackspot identification and treatment (Blackspot Management) are only one among the many road safety interventions to reduce road crashes and associated fatalities and serious injuries. It has to be borne in mind that only a certain level of reduction in road crashes will be possible through blackspot improvements. The concerned agencies may have to adopt various other interventions to achieve a sustainable reduction in road crashes in their respective jurisdiction. The other measures include road safety assessment, road safety audits and other non-engineering interventions like enforcement, road safety campaigns and post-crash care. Desirably a comprehensive road safety action plan in line with 'Safe System approach' has to be implemented which covers all aspects of road safety.

The task of preparation of these Guidelines was taken up by the Road Safety and Design Committee (H-7) during the tenure 2018-20. A subgroup under the Convenorship of Dr. Geetam Tiwari comprising Shri Jacob George, Shri Tony Mathew, Shri S.K. Popli, Dr. Sudeshna Mitra and Dr. S. Padma was constituted to prepare the draft. The draft was deliberated in various meetings of H-7 Committee and was finalized in its meeting held on 03.09.2020.

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The draft document was placed before the Highways Specifications and Standards Committee (HSS) in its meeting held on 12.09.2020 and continued on 19.09.2020 & 03.10.2020. The HSS Committee decided that the Convenor, H-7 Committee will modify the document based on written and verbal comments offered during the meeting and submit the final document to IRC for placing before the meetings of Executive Committee (EC) and Council. The EC in its meeting held on 18.02.2021 approved the draft document for placing before the Council. The 221st Mid-Term Council in its meeting held on 20th – 21st February, 2021 considered and approved the draft "Guidelines for Identifying and Treating Blackspots" for printing.

This guideline provides guidance towards identification of blackspots and improvement of road crash prone locations through engineering interventions. It would serve as a training aid / reference guide for road safety professionals involved in planning, designing and maintaining different categories of roads starting from expressways, national and state highways, and all categories of roads under urban and local bodies, as well as engineering consultants, contractors and concessionaires. The guideline also provides practical guidance in carrying out blackspot improvement programme. In simple terms, it gives a systematic process for identifying locations

with unusually high incidence of road crashes, analyzing the contributory factors and then designing and implementing engineering counter measures including monitoring and evaluation.

Considering the fact that the above subject area is an evolving concept in the Indian road sector due to inherent limitation in crash data collection, this document can be treated as a provisional guide for the identification and treatment of blackspots and hence should not be considered as a comprehensive reference. With more experience gained in treating blackspots in the country and also in monitoring the effectiveness of counter measures, guideline could be revised later.

2. ROAD SAFETY IMPROVEMENTS: VARIOUS APPROACHES

2.1 Safe Systems Approach

The Safe Systems Approach (SSA) is built on the premise that deaths and serious injuries are not acceptable in road systems and no road user should be exposed to the level of kinetic energy that may result in death or serious injuries in road system.This implies that the incidence of road crashes themselves can be accepted, but not their serious consequences. SSA has been promoted by The Netherlands as the Sustainable Safety and in Sweden as the "Vision Zero" policy. The Dutch experts[1] have explained the objective of Sustainable Safety is to prevent road crashes from happening, and where this is not possible, to reduce the severity of injuries as much as possible. This can be achieved by a proactive approach in which human characteristics are used as the starting point: a user-centric system approach as depicted in **Fig. 2.1**. These characteristics refer on the one hand to human physical vulnerability and on the other hand to human (cognitive) capacities and limitations. People regularly make errors unintentionally and are not always able to perform their tasks as they should. Furthermore, people are not always willing to comply with rules and violate them intentionally. By tailoring the environment (e.g. the road or the vehicle) to human characteristics, and by preparing the road user for traffic tasks (by training and education), we can achieve an inherently safe road traffic system.

Many countries which have accepted the SSA have been successful in reducing road crashes. The SSA has been further explored to define a long term target as "Vision Zero". The "Vision Zero" policy initially adopted by Sweden, targets to achieve zero fatalities on a stretch of road in the foreseeable future. Vision Zero accepts as a basic starting point, that human beings make conscious and subconscious mistakes. That is why road crashes are bound to occur and in this regard, safety work must in the first instance be directed at those factors which can prevent road crashes leading to death and serious injury which continues to rise despite the United Nation declaring the decade of 2011 to 2020 as the 'Decade of Action for Road Safety' aimed at bringing down the fatalities by 50 % by the end of 2020[2].

2.2 Key Principles of Safe System Approach (SSA)

The three key principles of SSA are:

- Principle 1 : Recognition of human frailmty

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[1]*Wegman, F. (2010). Putting people at the centre: How to improve road safety in the 21st century? The 20th Westminster lecture on Transport Safety; The Parliamentary Advisory Council for Transport Safety, London.*

[2]*However, the number of road crashes continued to spike in Low and Middle Income Countries (LMIC) which accounted for 90% of the road deaths and serious injuries. Considering the above scenario, 3rd Global Ministerial Conference on Road Safety (Ministerial Conference) held in Stockholm, Sweden in February 2020 has extended the 2020 target of 50 % reduction of road deaths and serious injuries to 2030.*

- Principle 2 : Acceptance of human error, and
- Principle 3 : Creation of a forgiving environment and appropriate crash energy management.

These principles make it clear that the system designers have ultimate responsibility for the design, and upkeep of the road transport system, and are thus responsible for the safety level of the entire system. There is ample evidence to suggest that road designs such as lane width, presence of shoulders, number of lanes and designs of median influence driving behavior (operating speeds, lane changes etc.). Therefore, design of roads play an important role in road safety and in this context, improved geometric design of road infrastructure could in turn improve road safety.

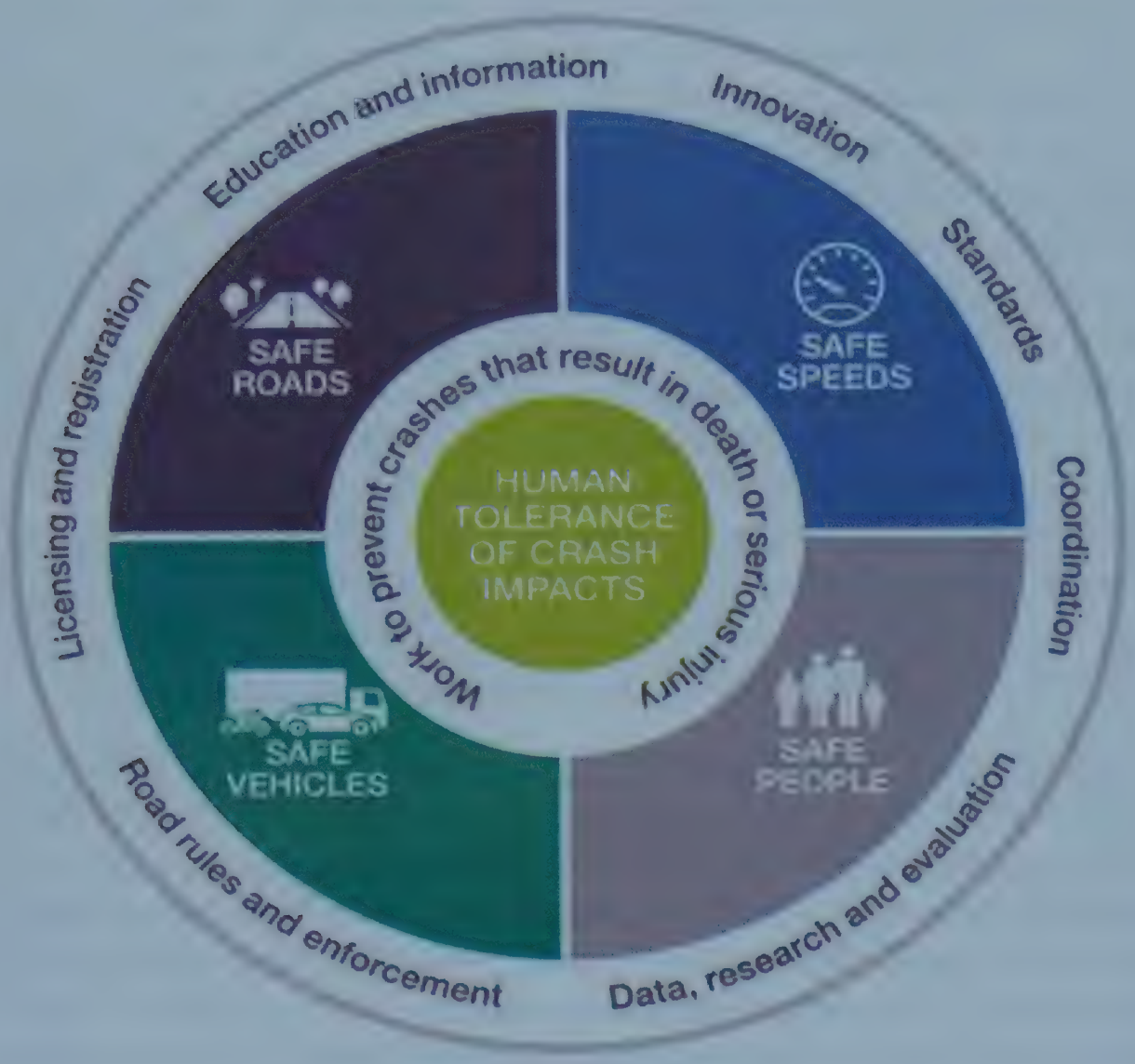


Fig. 2.1 Safe System Approach[3]

The blackspot improvement programme is an attempt to provide safe infrastructure, wherein engineering improvements and traffic control devices shall be designed and installed acknowledging the fact that road users can commit mistakes, dwelling in the underlying principles of 'Safe System Approach". Also, measures in blackspot improvement programme shall be designed and placed in such a way that in the event of a crash, it would not harm the road users seriously and the impact to the body would be well within the tolerance of human body. The measures of restriction imposed through blackspot improvement programme also shall acknowledge the human limitations and certain human behavior prevailing in the region or

[3]*Road Safety Strategy, 2015-21, Queensland*

State. So those who develop engineering and non-engineering counter measures for blackspot improvement programme shall adhere to the principles of 'Safe System Approach'

2.3 Engineering Interventions

The Safety Engineers are concerned with improvements to the road environment. Experience has revealed that it can be more effective to focus on the interaction between the human and the road environment. The following definition of a road crash gives us a clue as to how to do this:

"a road crash is a rare, multi-factor event always preceded by a situation in which one or more road users have failed to cope with the road environment, resulting in a vehicle collision."

The key words are "failed to cope with the road environment". It follows from this that road engineering should be helping road users to more easily cope with the road - its layout, safety features, and other facilities, etc. Engineers can do this by providing better signage and road markings, footpath, pedestrian crossing, speed controlling devices and channelization/ segregation, wherever possible. In some cases, it may be necessary to change the layout, alignment, etc., in order to make the road geometry simpler to understand and use. Even when road crashes cannot be avoided in certain situations, there is considerable potential to reduce fatalities and serious injuries through improvements in road engineering.

The following example may help illustrate why it is important to focus on solutions, rather than the direct causes.

A vehicle ran off the road at a sharp bend and the driver died due to the impact of the vehicle sliding down the high embankment on the valley side. The police investigation revealed that the driver had been travelling too fast as well as under the influence of alcohol at the time of the crash. Hence, they concluded that the above road crash was due to dangerous driving and influence of alcohol.

However, the Safety Engineers inspected the site and found that the sharp bend came after a long straight section, and that the "sharp bend warning sign" had not been replaced after it had been damaged in an earlier road crash. Moreover, a roadside safety barrier was not in place in the sharp bend in the stretch of high embankment to protect any errand vehicle. Experience has revealed that, if the sign had been in place, the driver could probably have avoided the above road crash and if the barrier were in place, even in the event of the crash, the death of the driver would have been avoidable. This is an example of a road crash situation where simple and cost-effective engineering solutions can save lives resulting from crashes. The police investigation often misses out these aspects.

In a blackspot improvement programme, the task is to identify where road crashes are happening and investigate them to determine the local risk factors involved so that appropriate and effective remedial measures can be applied. Taking the number of actual road crashes as the starting point is of fundamental importance, because it is not possible to reliably identify and analyze hazardous locations from the look of the road alone. Though the road crash data available in many States in India is not as comprehensive, precise and reliable as we would like it to be, but it is the only source of data to be relied upon.

Road crashes happen in many forms and in many locations. It is neither feasible nor useful to analyze each individual crash in detail. The key is to try and identify locations where an above-average number of road crashes are occurring showing a pattern of road crashes, as these are potentially worthwhile sites for investigation and treatment. Road Safety Specialists recognize following four main approaches to the task of treating roads with bad road accidents records:

- Single Site Scheme or Blackspot Programme
- Route Action Scheme
- Mass Action Scheme
- Area Action Scheme

Brief descriptions of these four safety engineering approaches are given below.

2.3.1 *Single Site Scheme or Blackspot Treatment Programme*

Single Site Scheme also called Blackspot Treatment Programme is a treatment of individual sites [e.g. junctions, bends, or short (500m) length of road] in which road crashes are clustered, with distinct pattern of crashes, which can be corrected by safety engineering interventions. In a broader sense, blackspot is defined as a road section of 500 m length or a junction that has the number of road crashes higher than the Average Annual Total Crashes (AATC) computed for the candidate road section considered in the study. It is an established phenomenon that such surge in the specific type of road crashes at the identified blackspot can be fixed through the implementation of appropriate engineering measures.

2.3.2 *Route Action Scheme*

In the route action, the safety treatments will be applied to the whole length of a road which has a bad overall road crash record. Based on safety assessment and audit, fixing all safety issues along a road section comes under Route Action.

2.3.3 *Mass Action Scheme*

Application of standard treatments to locations having incidences of common types of road crashes (e.g. provision of central refuges at pedestrian crossings on wide roads) is called Mass Action.

2.3.4 *Area Action Scheme*

In the Area Action, the safety treatments will be applied throughout an area (often a part/area of town) which has a bad overall road crash record (e.g. traffic management and traffic calming measures undertaken throughout a housing colony or a commercial zone/area).

3. BLACKSPOT TREATMENT PROCESS

In a blackspot improvement programme, road traffic crashes are analyzed spatially for a fixed period of years (ranging between 3 to 5 years) and where localized higher density of road crashes are identified (clusters), these can indicate that there are deficiencies with the road environment. If this high crash occurrence has been caused by a clear, physical road deficiencies, it is essential that such defects should be identified. There after, suitable remedial measures should be devised and undertaken to rectify the defects so as to reduce both the incidence of road crashes and fatalities on the identified road stretch. In many cases, the specific "Blackspots" can be rectified by engineering measures; as the rectification of blackspots should be accorded top priority by the road owning agency. The key phases in conducting the investigation and rectification of blackspots can be broken-down into five main stages:

- Crash data analysis and identification of initial candidate blackspot sites;
- Analysis of severity of crash at identified blackspots and prioritization of the list;
- Crash data analysis of individual sites and diagnosis of the causes of crashes and selection of counter measures;
- Detail design and implementation of proposed treatments; and
- Monitoring and evaluation

In this regard, the definition for treatment of the blackspots in various countries is given in **Annexure A** and it also presents a comparison of approaches being used by these countries. The technical process to be deployed for developing the suitable treatment for a blackspot is given in **Fig. 3.1.** As mentioned earlier, the technical process given in these Guidelines, including the road crash data collection dwells on engineering aspects only. It starts with prioritization of blackspots followed by detailed crash data analysis, for prioritized blackspots, site visit, and final diagnosis. This will suggest development of counter measures, their detailed design and implementation, followed by monitoring and evaluation.

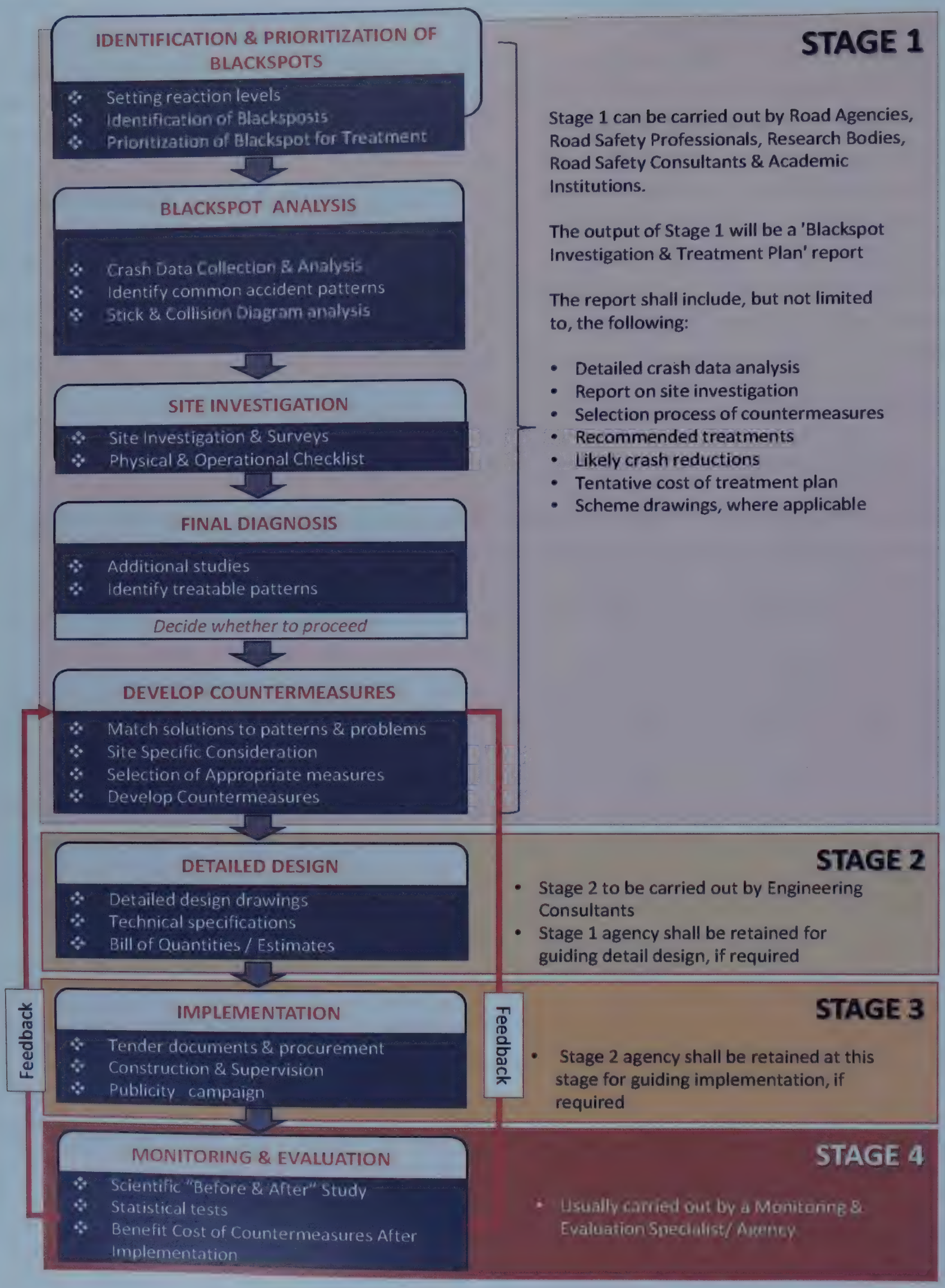

IDENTIFICATION & PRIORITIZATION OF BLACKSPOTS
Setting reaction levels
Identification of Blackspots
Prioritization of Blackspot for Treatment
BLACKSPOT ANALYSIS
Crash Data Collection & Analysis
Identify common accident patterns
Stick & Collision Diagram analysis
SITE INVESTIGATION
Site Investigation & Surveys
Physical & Operational Checklist
FINAL DIAGNOSIS
Additional studies
Identify treatable patterns
Decide whether to proceed
DEVELOP COUNTERMEASURES
Match solutions to patterns & problems
Site Specific Consideration
Selection of Appropriate measures
Develop Countermeasures
DETAILED DESIGN
Detailed design drawings
Technical specifications
Bill of Quantities / Estimates
IMPLEMENTATION
Tender documents & procurement
Construction & Supervision
Publicity campaign
MONITORING & EVALUATION
Scientific "Before & After" Study
Statistical tests
Benefit Cost of Countermeasures After Implementation
Feedback
Feedback
STAGE 1
Stage 1 can be carried out by Road Agencies, Road Safety Professionals, Research Bodies, Road Safety Consultants & Academic Institutions.
The output of Stage 1 will be a 'Blackspot Investigation & Treatment Plan' report
The report shall include, but not limited to, the following:
Detailed crash data analysis
Report on site investigation
Selection process of countermeasures
Recommended treatments
Likely crash reductions
Tentative cost of treatment plan
Scheme drawings, where applicable
STAGE 2
Stage 2 to be carried out by Engineering Consultants
Stage 1 agency shall be retained for guiding detail design, if required
STAGE 3
Stage 2 agency shall be retained at this stage for guiding implementation, if required
STAGE 4
Usually carried out by a Monitoring & Evaluation Specialist/ Agency

Fig. 3.1 Technical Process for Treating a Blackspot

4. BLACKSPOTS - IDENTIFICATION & PRIORITIZATION

4.1 Introduction

The identification of blackspots based on available road crash records for various types of roads in a state/union territory (referred generically as 'state' henceforth in this document) is one of the mandatory pre-requisities to undertake a blackspot improvement programme. This section presents a simple way to identify blackspots in different states in the country and presents a prioritization exercise based on total number of road crash types and injury severities of reported road crashes at all the identified blackspots. They are shortlisted to enable the road agencies to plan a Blackspot Improvement Programme which is to be implemented in a phased manner depending upon resources available. This would take care of the urgency by which blackspots are to be treated, as number and severity of road crashes have been accorded due consideration.

4.2 Crash Data Collection

Crash data collection is carried out across the road network only by the police in all the states of the country. This is because Crime Branch of Police are empowered to register the First Information Report (FIR) as per the statutory requirement. Additional data is collected by the police while investigating the case and a case file is prepared for the court for legal processing. It is primarily collected for legal purposes wherein the information is used in court cases as evidence where persons are fined or charged in relation to crashes. The FIR information is invariably required as part of the insurance claim procedure to allocate responsibility. In its simplest form, the police FIR will include a narrative description about the road crash.

As of now, many states still collect road crash data manually using the conventional First Information Report (FIR) format of Police. Since 2009, the Ministry of Home Affairs (MHA) has been working on the Crime and Criminal Tracking Network Systems (CCTNS). This is to automate police functions at police station and higher levels, as also create facilities and mechanism to provide public services like registration of online complaints, ascertaining the status of case registered at the police station, verification of persons etc. CCTNS is a national system for recording FIRs electronically. The format of each FIR is standard and same for all kinds of crime/accidents which are generally registered. Road Accidents FIRs are also being maintained in this CCTNS by most of the states. In the recent past, some of the states have implemented GIS enabled web based Road Crash Data Management Systems conforming to IRC:53 or formats recommended by MoRTH[1]. GIS enabled crash data management systems helps to identify exact location of crashes and it enables different types of crash data analysis and help the road agencies to develop evidence based road safety interventions to treat blackspots or hazardous locations.

4.3 Defining Blackspots for Identifcation

In a broader sense, blackspot is defined as a road section of 500 m length or a junction that has the number of road crashes higher than the Average Annual Total Crashes (AATC) computed for

[1] *https://morth.nic.in/sites/default/files/ASI/Revised_Road_Accidents_Data_Recording_and_Reporting_Formats.pdf*

the candidate road section/network considered in the study. More precisely blackspot is a road section of 300–500 m length that has an abnormally high number of road crashes showing a pattern of crash types due to some underlying local risk factors. To identify the blackspots, one of the first tasks is to identify that location in road network or road corridor where the number of road crashes are above average. The NHs, SHs and other roads in various States passes through different types of geographical terrain, where traffic volume, composition, speed and land use patterns vary significantly. The volume of traffic in most of the NHs/SHs are substantially high and hence the crash frequency and fatalities are high which is corroborated by the fact that the above classes of highways (including expressways) continue to account for the 55 to 60 % of the overall crashes and deaths during the last decade. Considering the above fact, a uniform guiding value cannot be applied across the country for identifying blackspots and the guiding rationale has to be state specific as well as according to the road class. In order to arrive at the average value for a state and specific road class; in the absence of quality and reliable data, a simple method based on annual average total crashes[2] has been chosen to determine the criterion for finding blackspots in various states.

4.3.1 *Average Annual Total Crash Values*

The stepwise process followed in determining Average Annual Total Crashes (AATC) is as follows:

i) Three-year fatality data is collected from official sources (like MoRTH) for the respective states covering the number of road crashes in major types of roads namely, Expressway (if passing through the candidate state), National Highways (NH), State Highways (SH) and Other Roads (OR);

ii) The road lengths of the above types of roads for candidate state is collected from official website of MoRTH;

iii) Annual Average Total Crashes (AATC) collected over 3-year period are divided by respective road lengths to get AATC/Km;

iv) AATC/Km is further divided to get AATC for 500 m of road length; and

v) AATC/500 m is multiplied by suitable factors (3 to 15 times described in Clause 4.3.2) to arrive at a number for the particular state considered in the analysis.

4.3.2 *Setting Reaction Level*

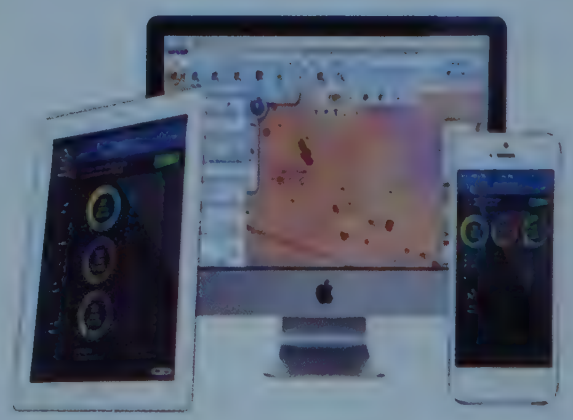
As mentioned earlier, any blackspot should be identified based on the road section that has more than the Average Annual Total Crashes indicated in **Annexure B**, which is state specific and also based on road category. The reaction level for identifing for the blackspots could be 3 times or 5 times or 10 times or 15 times. The actual number of road crashes in a segment of 500 m on the identified type of road for the past 3 to 5 years would be compared with AATC indicated in **Annexure B** to understand whether the road section with a cluster of crashes falls under the category of blackspot or not. Those road sections (with crash clusters) securing more than 15

[2]*Based on 2016-18 crash data available in MoRTH publication, which would be updated by States based on recent data*

times AATC can be termed as 1st order blackpsots whereas that between 10 to 15, times AATC and 5 to 10, times AATC and 3 to 5, times AATC are termed respectively as 2nd, 3rd and 4th order blackspots. Though many blackspots can be thus identified, it shall be prioritized further for actual execution under blackspot improvement programme.

4.4 Identification of Blackspot using a Crash Data Management System

In a state road network that have implemented a Crash Data Management System or a Road Safety Management System, blackspots can be identified through various methods including spatial analysis, cluster analysis, grid analysis, corridor analysis, etc. The methods used aim to identify road sections which have higher number of crashes occurring on them compared to other road sections. The methods that can be used differ according to the quality and type of location information available for road crashes, and the nature of the network being screened. For instance, in the case of a dense urban network, an elaborate approach would be needed as compared with a rural network. The methods and modules available in different crash data system packages software vary. Clustered crash locations can be identified on GIS map in a road crash management system, and the following sections outline some of the more common methods used for it.



4.4.1 *Cluster Analysis*

This method effectively finds discrete areas of higher crash densities. This method can be undertaken using any standard crash data management system. In this method, crash database or GIS software search a fixed radius or distance from each individual crash and if there is another crash which falls within this buffer distance, they are clustered together. An example of cluster analysis in a standard crash data management system is shown in **Fig. 4.1.** The program continues to cluster crashes until no more are within the specified range. This system is simple to understand and produces a series of crash cluster sites with defined, but variable, lengths along the roads or at the junctions.

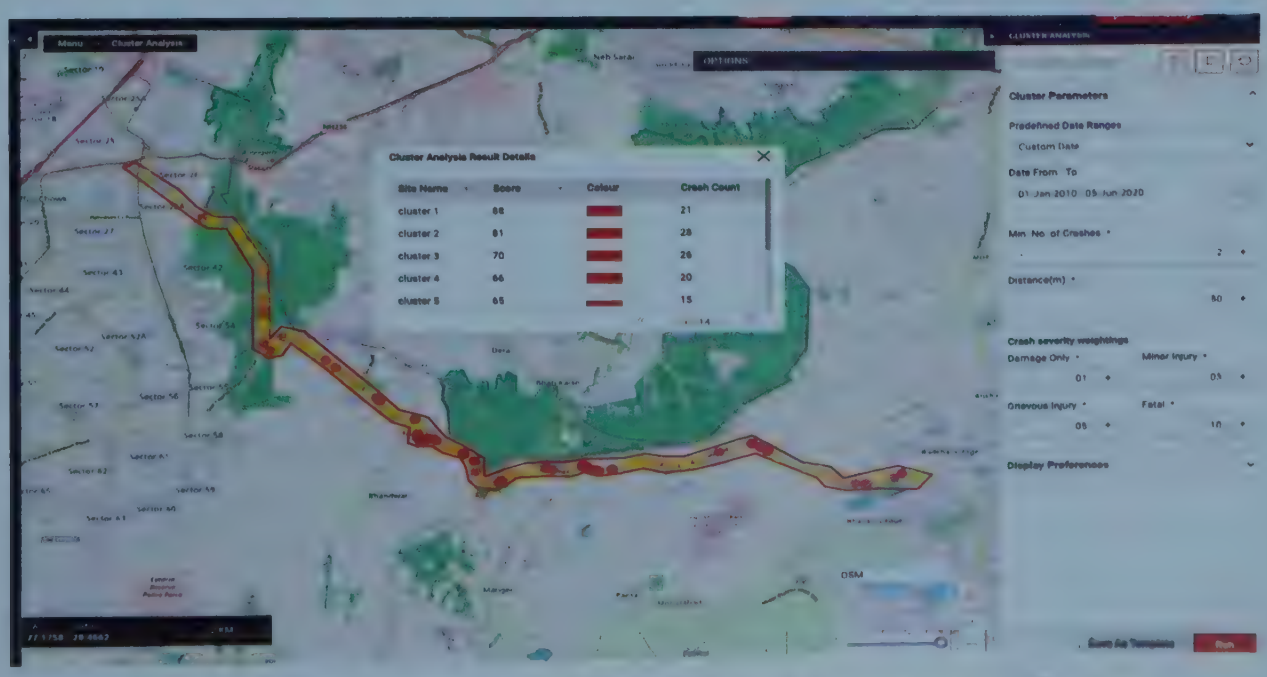


Fig. 4.1 Cluster Analysis in a Crash Data Management System

4.4.2 *Heat Map Analysis*

The heat map method produces an overlay over the road network which shows the areas of higher crash densities with 'hotter' or brighter colours. Superficially, the results are similar to the crash density method; however this method requires some additional user interpretation to decide which sites are the worst and what their extents or lengths are. This method is commonly available in a range of GIS packages. An example of heat map in a standard crash data management system is shown in **Fig. 4.2**.

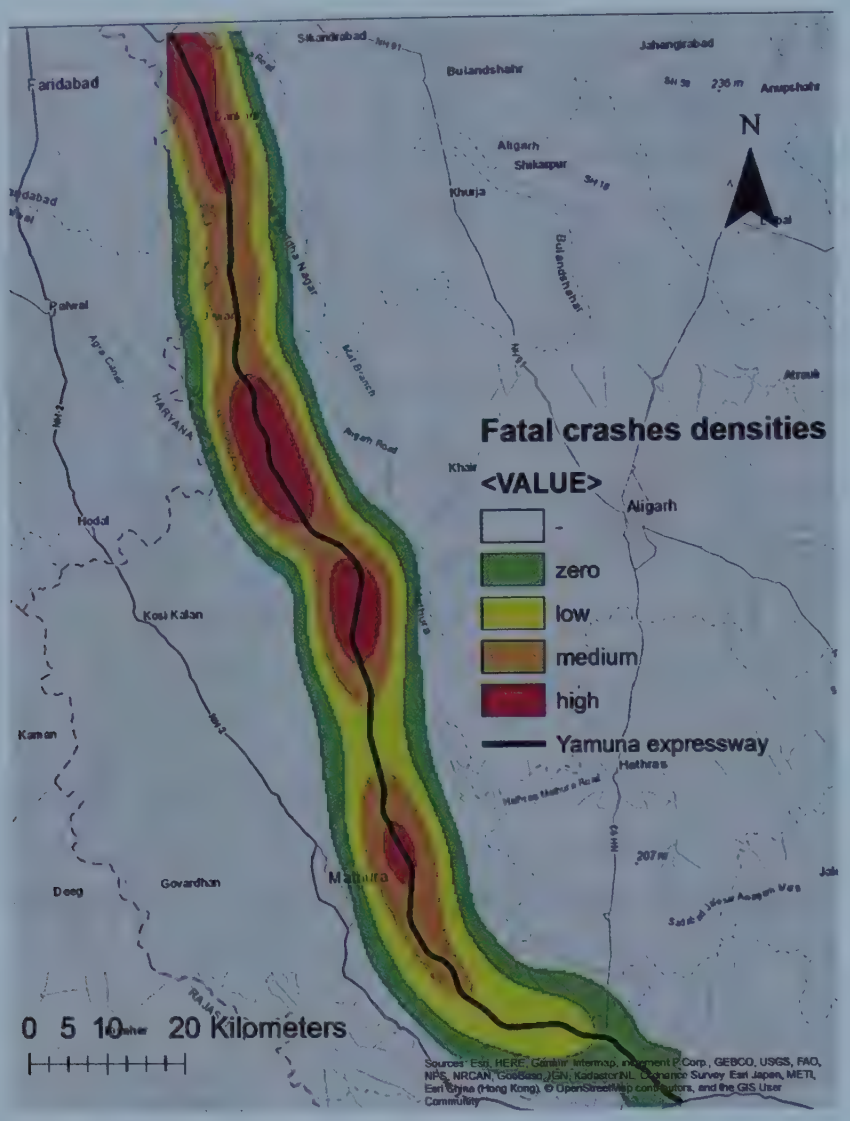


Fig. 4.2 Typical Crash Heat Map Generation from a Crash Data Analysis

4.4.3 *Corridor Analysis*

Corrridor analysis can be done on any user specified road length in any road section. The user can specify a start and end point on any given road in the road network and identify various information related to crashes–crash types, affected users, vehicle types, involved, crash timing etc. in the selected corridor. Some of the crash data systems would be able to identify road sections having variable lengths in which number of crashes occur frequently in a user defined period of time.

For blackspot identification referred to in Section 4.3 and **Annexure B,** the user should specify a fixed length to prepare corridor analysis. Those clustered locations securing above average fatality per 500 m as indicated in **Annexure B** would then be identified as blackspots and further identified for prioritization exercise. An example of Corridor Analysis from a standard crash data management system is shown in **Fig. 4.3.**

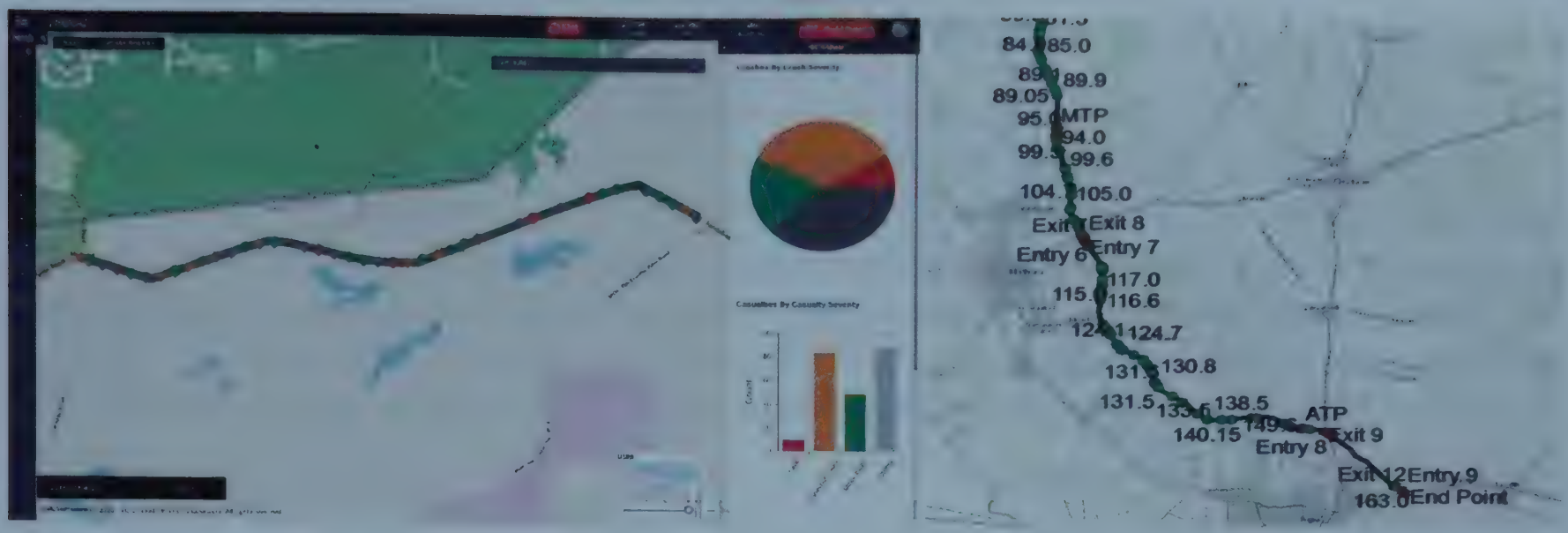


Fig. 4.3 Typical Corridor Analysis using the Crash Data System

4.5 Prioritization of Blackspot for Treatment

All blackspots that are identified may not be taken up for rectification immediately, due to budget constraints. The identified list of blackspots has to be prioritized for treatments in a given financial year to match with the available budget. By prioritizing the identified blackspots, the road agencies can schedule a blackspot improvement programme to be executed in different stages depending upon the resources available with the agencies. This prioritization task should be carried out based on severity indices as described in the succeeding sections.

4.5.1 *Severity Indices*

A blackspot site will have different numbers of crashes, with different severity. Depending upon the severity of any road crash, severity score shall be assigned with the values as given below:

- Fatal Road Crashes - 10 points;
- Serious Injury Crashes - 5 points;
- Minor Injury Crashes - 2 points; and
- Damage Only Crash -1 Point.

A blackspot with a higher severity score shall be piortised for treatment over the other crash locations. For example, if there are 15 blackspots under consideration for immediate implementation, the blackspots shall be prioritized by the descending order of severity score.

The severity indices indicated are for the prioritization exercise, to guide authority to choose a set of blackspots for immediate action. Hence flexibility lies with the authority to assign different severity indices for fatal, serious injury, minor injury and 'damage only' crashes. The authority can choose all crashes such as fatal, serious and minor injury and 'damage only' crashes for prioritization exercise or authority can chose to dispense with 'damage only' crashes in the prioritization exercise. If there is a situation where two crashes clustered locations secured same total severity score, both should be taken, and it would be upto the discretion of Authority, as it is a matter of fund available with the Authority.

4.5.2 *Worked out Example for Prioritization*

The example in **Table 4.1** shows fifteen crash clusters (i.e. identified blackspots) in a given road network. A total severity score has been derived for each cluster by assigning severity scores for the severity of each crash as given in Section 4.5.1. Once total severity score is calculated, the same can then be arranged in descending order to shortlist blackspots as presented in **Table 4.1.** Those blackspots which has secured the higher severity score shall be taken up for immediate treatment and others in various stages depending on the availability of funds for blackspot treatment but in any case treatment should be completed within 2 years from the identification of blackspots.

Table 4.1 Worked out Example for Total Severity Score

Location	Number of Accidents				Total Severity Score
	Fatal	Serious	Minor	Damage Only	
	Severity Score				
	10	5	2	1	
Accident Clustered Location 1	1	3	2	3	32
Accident Clustered Location 2	0	10	5	0	60
Accident Clustered Location 3	5	2	3	7	73
Accident Clustered Location 4	0	1	2	7	16
Accident Clustered Location 5	0	1	0	2	7
Accident Clustered Location 6	0	0	2	1	5
Accident Clustered Location 7	8	0	1	1	83
Accident Clustered Location 8	1	1	2	8	27
Accident Clustered Location 9	1	1	3	5	26
Accident Clustered Location 10	0	0	4	2	10
Accident Clustered Location 11	2	2	3	12	48
Accident Clustered Location 12	2	3	1	10	47
Accident Clustered Location 13	0	0	0	6	6
Accident Clustered Location 14	2	0	3	2	28
Accident Clustered Location 15	7	5	0	0	95

Table 4.2 Blackspot for Treatment in the Order of Priority (Worked out Example)

Location	Number of Accidents				Total Severity Score	Black Spot Treatment in Order of Priority
	Fatal	Serious	Minor	Damage Only		
	Severity Score					
	10	5	2	1		
Accident Clustered Location 15	7	5	0	0	95	Black Spot 1
Accident Clustered Location 7	8	0	1	1	83	Black Spot 2
Accident Clustered Location 3	5	2	3	7	73	Black Spot 3
Accident Clustered Location 2	0	10	5	0	60	Black Spot 4
Accident Clustered Location 11	2	2	3	12	48	Black Spot 5
Accident Clustered Location 12	2	3	1	10	47	Black Spot 6
Accident Clustered Location 1	1	3	2	3	32	Black Spot 7
Accident Clustered Location 14	2	0	3	2	28	Black Spot 8
Accident Clustered Location 8	1	1	2	8	27	Black Spot 9
Accident Clustered Location 9	1	1	3	5	26	Black Spot 10

Accident Clustered Location 4	0	1	2	7	16	Black Spot 11
Accident Clustered Location 10	0	0	4	2	10	Black Spot 12
Accident Clustered Location 5	0	1	0	2	7	Black Spot 13
Accident Clustered Location 13	0	0	0	6	6	Black Spot 14
Accident Clustered Location 6	0	0	2	1	5	Black Spot 15

Wherever crash data is available in a Crash Data Management System, priority shall be given to such clusters wherein a particular crash type is predominant among all the crashes noted in those clusters.

5. BLACKSPOT ANALYSIS

5.1 Detailed Road Crash Data Collection

The crash types for prioritized blackspots should be investigated to identify any patterns in the occurrences of the crashes. The purpose of crash data collection is to help the blackspot investigating team to come up with the identification of causes and nature of road crashes. Ideally, crash data for a minimum of 3-year period (preferably 5-year period) should be collected for the purpose of analysis. The crash types and other common factors (time, road geometry, etc.) will provide clues to diagnose the underlying problems at the site and to suggest the development of a treatment plan for solving the underlying issue. Crash data analysis is very important, as it enables identification of predominant crash types in a blackspot location and subsequent selection of matching counter measures.

For collecting crash data, the investigating team should necessarily visit the Police Station and gather data from the FIR of each case of road crash for the shortlisted blackspots. The crash data thus collected shall be studied with the help of Police and a summary analysis shall be prepared in a spreadsheet. Attributes and terminology used for crash data collection and analysis is presented in **Annexure C.** In the case of states or districts where Crash Data Management System has been implemented, the predominant pattern of crash types and other common attributes can be obtained using Stick Analysis feature available in a Crash Data Management System.

5.2 Prepare Summary Analysis

A summary report which shows a range of the key information on a single report is extremely useful. There are a number of key information types that can help diagnose the most common issues at a site. The typical information included is as follows, but not limited to:

- Type of crash
- Severity of crash
- Type of victims
- Type of vehicle involved
- Type of injuries
- Time of crash (Day/Night)

The objective of summary analysis is to look for a pattern or patterns in road crashes, if any, which might help to identify one or more contributory factors due to underlying local risk factors. For each site, one summary analysis will be developed which would be helpful for the team to get clues regarding pre-dominant collision type, severity and time of road crash as well as the surface condition of the road at the time of crash occurrence. Ideally, these data should be displayed efficiently and in a standard format so that a large amount of information can be quickly assessed to identify any clear pattern and trend. An example of summary analysis is given in **Table 5.1.**

Table 5.1 Example of Summary Analysis

Collision	Crashes						Damage accident 3-yr Total	Crashes 3-yr Total			
	Year			3-yr Total	%	Av. Annual		Fatal	Serious Injury	Minor Injury	All
	2017	2018	2019								
Head On	2	0	0	2	10		0	2	1	5	8
Rear End	0	0	0	0			0	0	0	0	0
Right Angle	0	0	0	0			0	0	0	0	0
Side Swipe	0	1	0	1	5		1	0	1	2	3
Overturned	0	1	1	2	10		1	0	1	16	17
Hit Object on Road	0	1	0	1	5		0	0	0	1	1
Hit Object off Road	0	0	0	0			0	0	0	0	0
Hit Parked Vehicle	0	0	0	0			2	0	0	0	0
Hit Pedestrian	2	2	2	6	30		0	4	1	1	6
Other	3	5	0	8	40		3	1	35	14	50
Total	**7**	**10**	**3**	**20**		**6.7**	**7**	**7**	**39**	**39**	**85**
Night				4	20		4				
Day				16	80		3				
Wet				3	15		1				
Dry				17	85		6				

These reports can be produced semi-manually as well by performing the appropriate cross-tabulations and filling in a form in a spreadsheet or similar tool.

5.3 Stick Diagram Analysis

Stick Diagram Analysis allows the investigation team to view groups of crashes with each individual record being represented by a column or 'stick' of information. The main purpose of Stick Diagram Analysis is to determine a pattern in crash type or any other factors due to localized risks leading to crashes in that particular location where cluster of crashes occur. A stick can be created using any information user wants, but the most usual ones are collision type, injury severity, affected user, time of the day, road surface condition, and weather. By moving these 'sticks' of information around, or highlighting similar factors, the investigating team can often discover patterns in the crashes at a particular location and this can help them to identify

the underlying causes. The sticks can be produced by hand as well as the diagrams being drawn from the individual records by pen or pencil on simple paper as shown in **Table 5.2**.

Table 5.2 Stick Analysis using a Spread Sheet

Accident No.	1	2	3	4	5
Reference No.					
Date	01-04-2009	04-04-2009	05-04-2009	06-04-2009	15-04-2009
Day	Wednesday	Saturday	Sunday	Monday	Sunday
Time	6:55 p.m.	7:00 p.m.	6:30 p.m.	3:10 a.m.	01:00 p.m.
Severity	Serious Injury	Minor Injury	Serious Injury	Minor Injury	Fatal
Dark/Light	Darkness	Darkness	Darkness	Darkness	Day Light
Weather	Fine	Fine	Fine	Fine	Light Rain
Road Feature	Four Lane	Four Lane	Four Lane	Four Lan e	Four Lane
No.of Vehicles	1	1	1	1	2
Vehicle 1	Two Wheeler	Truck	Car	Truck	Two Wheeler
Vehicle 2	Car	Two Wheeler	LCV	Truck	Trailer Truck
Vehicle 3					
No. of Causalities					1
Type of Area	Rural	Rural	Rural	Rural	Rural
Description of Collision	Two wheeler travelling on a straight road met with a rear end collision with a car	Over speeding by Truck resulted in head on collision with two wheeler	Car travelling on a straight road met with a rear end collision with a Light Commercial Vehicle	Truck travelling on a straight road met with a rear end collision with a Truck	Over speeding led to head collision of two wheeler and trailer truck
Type of Collision					

Using specific stick analysis features available in the crash data systems of various software, one can make stick sorting and shuffling easier and the addition of different fields can be done much more quickly and flexibly. The sticks can use simple abbreviations or the numerical values for the fields of interest to show a great deal of information on a single sheet with the use of icons and different colours which will make the information more legible for quick assessment.

6. SITE INVESTIGATION

6.1 Site Visit

It is mandatory for investigating team to make thorough inspection of the blackspot site where road crashes have occurred. Such inspection would largely help in understanding the causatives

factors for the road crashes that would not be evident from the study of road crash and fatality data alone. Ideally, such site visit should be undertaken after making a proper analysis of road crash data drawn from FIR records. The road crash reports and analysis details will be carried to the site for understanding whether inferences drawn from the analysis match with the actual site condition. The two main reasons for doing the site inspection are i) to accurately assess the road conditions and other site factors which may be relevant; and ii) to actually experience the problems that road users are facing.

Ideally, the engineering investigating team should walk as well as drive through the site in both day and night-time conditions. The effort should be to understand why certain road users are failing to cope with the situation. Take as many date and time stamped photographs of the site and each approach and if possible take videos of the drive through in day and night conditions, as it can be difficult to visualize the site exactly once the investigation team is back in the office. Since road crashes are multi-factor events, investigating team has to look beyond what may be the obvious causes. They should search for underlying factors for which there are known and matching counter measures. In many cases these underlying factors will not appear in the road crash form. Common examples include:

- Uncontrolled junction where need of vulnerable road users including pedestrians are neglected.
- Y junction causing high speed turning from main road to side road and side road to main road
- Median plantation obscuring the visibility of the junction
- Obstructions to visibility such as parked cars, roadside furniture, trees etc
- Lack of visual clues, e.g., it is difficult to recognize that there is a bend or junction ahead
- Lack of pedestrian facilities.

Talking to the local people who live and work near the site can often be very rewarding, as they may have witnessed many of the road crashes. At the same time, what they say may not be fully reliable. It is always useful to get the views of the Police as well as the engineer responsible from the road owning agency.

6.2 Recording of Findings

Video cameras, or digital cameras and voice recorders, enable images of the site to be recorded along with a spoken commentary of issues. This is extremely useful when later collating the observations and the images can also form a very informative part of the report. It is recommended that a full video of the site/road is recorded along with date and time stamped photographs are also taken during the site visit. These are important in order to provide a reminder of key issues when writing the report and provide a record of the conditions during the site visit.

Taking videos and photographs in a systematic manner will help when reviewing them later. Always start a video sequence speaking to the camera and naming the site, identifying the personnel involved, stating the date and time and by specifying direction of travel. It can also be helpful to provide a video commentary. As mentioned earlier, date and time stamped photographs should be taken in a sequential manner so as to assist subsequently in identifying features and

locations. For example, ensure that landmarks are included and always progress around an intersection in a clockwise direction. It may also be helpful to photograph a written card which describes the location prior to taking a sequence of photographs. Copies of plans should also be used to record any specific features seen during the visit for later reference. Engineering investigation team desirably should bring the following items for the site visit:

- A camera for site photography capable of capturing the date and time stamped photos. It is desirable to have the Global Positioning System (GPS) coordinates embedded on the photographs which would help to align with the ground coordinates.
- Measuring Tape or distance measuring wheel or any form of laser based distance measuring device for the measurement of short distances up to 50 m or so.
- A radar/laser gun for measurement of Spot Speeds. Whenever such speed data is collected it is essential that a minimum sample size of 30 numbers should be captured across varying vehicle types to establish the requirement of statistical significance of the collected data. Further, such data collection should be carried out by the team by camouflaging themselves from the traffic so that any drastic reduction in speed is not witnessed.
- Pen/pencil and a survey pad for recording details;
- Survey plan or scheme drawings on which site details; can be plotted;
- Reflective/safety jackets; and
- Copies of the Site Investigation Form.

The following safety protocol shall be followed for all site visits:

- Ensure personal safety/team safety (e.g., wear reflective jackets, pay attention to the movement of traffic, if working on the carriageway; have someone next to the team member, whose sole duty is to watch for the oncoming traffic from all the directions); and
- Ensure public safety (e.g., do not park on the road, obstructing traffic, or obstructing the visibility of other road users, and switch hazard / blinker lights on the vehicle at the time of parking).

6.3 Site Investigation Form

The Investigation team shall use site investigation form in which details will be marked. These may include the typical aspects like obstructions to the visibility, lack of visual clues, uncontrolled junction maneuvering, visibility funnel (in the case of intersections and curve) and lack of pedestrian facilities, etc. need to be recorded clearly to understand why the vulnerable road users are failing to cope up with the situation. It shall contain the details such as name of the road, presence of various facilities like Market, Schools, Bus Stops, Shops and Parking (if any), presence of road humps, hazardous pot holes etc, which are desirably already recorded when an as-built drawing or a new topographic survey is used.

6.4 Site Investigation Checklists

While investigating the site, both physical checklist and operational checklist will have to be used.

The checklist will pose questions to be answered during the site visit. Physical and Operational Checklists are given respectively in **Annexure D** and **Annexure E**. Checklists recommended in IRC:SP:88 may be referred to for additional guidance.

6.5 Additional Surveys and Studies

Sometimes, it is necessary to carry out all the following or some of the listed additional surveys in order to help confirm analysis results and prepare the way for designing counter measures. These include:

- Detailed examination of witness statements in the Police case file. In the case of a crash data management system, additional details can be extracted.
- Traffic counts and surveys of classified turning volume counts at mid blocks/junctions covering all turning movements (always necessary before redesigning the junctions)
- Pedestrian counts (to understand desired path of pedestrians to cross the road) as well as the number of pedestrians along the road in terms of identifying which side of the road they use.
- Surveys of pedestrian crossing behaviour (Do they cross in one movement or stop in the middle? - What do they find most difficult? - Do they make a detour to find a safer place to cross?)
- Measurement of visibility distances.
- Spot speed surveys.
- Conflict studies (observing the interaction of traffic (including pedestrians) at a site and recording the conflicts or "near-misses")
- Topographic survey with necessary features wherever required.

7. FINAL DIAGNOSIS AND DEVELOPMENT OF COUNTER MEASURES

7.1 Final Diagnosis

Based on the crash data analysis and further detailed site investigation, the blackspot investigation team is expected to come out with diagnosed problems for each of the blackspot site. The findings have to be drawn and clearly expressed with sound reasoning, because these are the basis for selecting the counter measures. The underlying aim is to identify the contributory factors tackling of which might be able to change the situation.

7.2 Identify Treatable Problems

The treatable problems which have matching counter measures shall be listed out at this stage. A second visit should be undertaken to assess the appropriateness of analysis and the findings. The analysis should always yield results with two types of locations such as:

i. Locations where distinct problems are identified

ii. Locations where the analysis are inconclusive

Where clear problems are identified, the team should proceed to the next task. In case, the

analysis does not identify distinct problems, the site will be further investigated or next most serious hazardous location will be considered. If ITS facilities are already installed in a blackspot location, the details recorded therein may be analyzed to precise problem diagnosis. The use of speed camera also can be considered as an enforcement counter measure to reduce speed.

7.3 Development of Counter Measures

7.3.1 *Match Solutions to Diagnosed Problems*

If one or more dominant type of road crash types have been identified to be the root cause for the increased frequency of crashes and the analyses have reached some conclusion about the causal factors involved (and these causes are capable of being treated or remedied), it is then required to match solutions (counter measures) to the problems. The solutions should accomplish at least one of the following:

- Remove the conflict causing the problem;
- Improve the situation (e.g., provide warning earlier so that road users can cope better);
- Reduce the speed, thus reducing the crash risk and its severity and
- Adhering to the first principle for safe design in case of priority, roundabout and signalized intersections

7.3.2 *Site Specific Consideration*

When suggesting counter measures, following consideration should be taken into account:

- Is the remedy cost-effective? - Some measures may be effective without being cost-effective. Generally black spot improvement proposal begins with implementing low-cost measures. In many cases high cost solutions may be kept in abeyance to make it financially viable in the initial period of upgrading the highway, which may have created the risk. While black spot improvement is intended to be a low cost engineering intervention; however, if a high cost measure is really warranted for a specific location to address a specific problem, it shall be adopted through a proper cost benefit analysis. Low cost solutions may still be provided as an interim measure.
- Is it adhering to first principle for junction layout design for safety? - Junction layout shall adhere to the safer practices suggested in relevant IRC documents (IRC:SP:41, IRC:SP:73, IRC:SP:84, IRC:SP:87)
- Is it likely to be long-lasting? - Some speed-reduction measures for example have an immediate effect but this wears off as drivers get used to them;
- Will it result in an excessive increase in other types of crashes? - For example, in some circumstances the introduction of traffic signals can result in an increase in rear-end collisions;
- Will it need to be heavily enforced by the Police or need considerable publicity and education? -If so, consider whether this is really achievable.
- Will it be user friendly for pedestrians and other vulnerable road users?: For example, a

FOB in rural section, seemingly can avoid all crashes related with pedestrian crossing, but pedestrian tend to cross the road at-grade owing to the fact that efforts required to use FOB is many fold compared with an at-grade crossing.

7.3.3 *Selection of Appropriate Measures*

As such, counter measures for blackspot improvement can be classified as short-term and long-term measures. Those measures that are capital intensive like proposal for grade separators are termed as long-term measures.Those measures which are low cost in nature are termed as short-term measures. Short term measures can give immediate benefits. Though long-term measures are capital intensive, it should be understood in proper context in highway development in the country and hence provision should be made for its implementation in the foreseeable future.

Historically in many highway development projects in India, the high cost solutions have been removed while implementing the project to make it financially viable and some other cases due to land acquisition issues. Due to any reasons, if these high cost solutions were not implemented, it would have manifested site specific risks leading to creation of blackspot in the operational and maintenance period of the project. If a high cost solution is technically warranted, it shall be recommended after carrying out appropriate cost - benefit analysis based on the particular merits that it can reduce the incidence of road crashes substantially.

7.4 Counter Measures

It has been proven that certain engineering treatments, if implemented properly, are very successful in reducing certain common crash types. These engineering treatments are generally known as counter measures. The most commonly occurring crash types are as follows:

- Single vehicle crashes (crashes such as ran-off, overturning, etc.)
- Pedestrian crashes
- Crashes for vehicles driving in the same direction (usually rear end collisions, side swipe, etc.)
- Crashes at junctions (usually right-angled collisions)
- Crashes between vehicles travelling in opposite directions on undivided roads (usually head-on collisions)
- Railway crossing crashes

It is highly likely that in most of the blackspots[1], any one of the above crash-type will be predominant. In such a situation (where a predominant crash type can be observed), it could be usually because of the local risk factors present in the blackspot . Such frequently occurring crash types can be treated by matching counter measures (engineering interventions). For each crash type listed above, the likely contributory factors along with potential counter measures are given below.

[1]*It could be possible that certain blackspots will not have any predominant crash type. In such a situation, all risk factors on that particular road environment have to be assessed and a wide-ranging safety treatments have to be proposed.*

7.4.1 *Single Vehicle Road Crashes*

The usual two sub-types of single vehicle road crashes are:

a) Ran-off road (no collision); and

b) Hit object on/off the road.

Likely Contributory Factors	Possible Counter Measures	
• Excessive speed not matching the road environment • Driver fatigue • Poor lighting/ Dark conditions • Road alignment is unclear • High speeds on curves • Restricted forward visibility for the actual approach speed • Narrow carriageway width after a long wide section • Sharp sag or crest curve • Incorrect super elevation • Tree / pole / bridge parapet / other hazard is too close to the edge of the road and is poorly marked • Objects closer to road not visible in dark conditions	Speed limiting measures	• Install vertical speed calming measures[2] - rumble strips, bar markings, speed breakers, speed tables, etc., with traffic signs, as appropriate. • Provide speed limit signs and initiate speed enforcement (supported by wide campaigns). • Install warning signs along with Advisory Speed Limit, as per IRC:67. • Install Chevron sign or delineator posts, as per the stipulated spacing depending on the radii. • Consider applying speed limits.
	Improve signing[3]	• Ensure that all traffic islands, medians conform to the requisite road signs and markings as per relevant IRC Codes/ Standard • Install hazard markers on obstructions close to the edge of the road and / or paint the obstruction with black and yellow stripes. • Install clearly visible junction warning signs before all junctions.
	Improve road markings[4]	• Mark centre and edge lines. • Apply hatch markings in advance of medians and traffic islands to guide the drivers through the lane. • Mark STOP lines or Give Way lines at all junctions; Where 'Stop' road markings are provided, it shall be supported with a 'STOP' sign.
	Improve visibility	• Remove bushes, trees, advertising boards/ hoardings,if they are obstructing visibility. • Consider installing street lighting if the site is located in urban area or even in the case

[2]Vertical speed reduction measures shall be provided as per IRC standards; In no case, non-standard speed reduction measures shall be provided and all speed reduction measures shall be as per IRC:99.

[3]While installing signs, it is to be ensured that traffic signs placed at locations visible to all approaching drivers and signs are not cluttered; Too many traffic signs at a small sections runs the risk of drivers ignoring all the signs provided.

[4]For road marking guidelines, refer IRC:35

Likely Contributory Factors	Possible Counter Measures	
• Steep gradient • Potholes or depressions in road surface • Road surface is slippery when wet • Slippery road surface due to debris on the road • Ponding of water on the road • Attempt to avoid collision • Traffic island that is difficult to see • Forward visibility is hampered due to the parked vehicles, in particular on the inside edge of carriageway on the curves		of the site having a history of night time crashes. • Remove the median plantation at (1) those curves which obscure the forward visibility while negotiating the curve and (2) at least 20 m on either side of median openings. • Anti-glare measures can be installed on the paved road medians based on road environment, to reduce headlight glare from opposite traffic as per relevant codes for 4/6 lanes highways. Anti-glare screen shall be highlighted with retro-reflective tape for achieving enhanced visibility during night and adverse weather conditions.
	Soften the roadside environment	• Remove roadside obstacles or move them further back from the road. • Consider installing crash barrier/crash attenuators[5] with retro-reflective tape for visibilityat night and adverse weather condition. • Consider re-forming embankments and cuttings to make the side slopes less steep.
	Improve the geometry	• Eliminate sharp changes in alignment - realign the road completely - use transition curves. • Ease gradient; Correct the gradient in locations where horizontal bend comes after a crest in the vertical gradient[6]. • Provide extra widening at curves as per IRC standards. • Correct the super elevation, if found faulty.
	Improve the road surface	• Rectify potholes and repair damaged edges. • Improve drainage if water ponding is a cause of crashes or pothole formation. • Improve skid resistance, especially if there is a high incidence of wet weather crashes.
	For crashes involving parked vehicles	• Consider parking regulations; consider removing on-street parking on locations where the crashes involving parked vehicles are high. • Consider conversion of angled parking to parallel parking • Consider increasing the clearance between the parking bays and through traffic lanes.

[5]For appropriate installation of crash barrier, refer to IRC:119
[6]This is a common road geometry hazard observed in most of the hilly roads in India

Likely Contributory Factors	Possible Counter Measures	
		• If many of the crashes are at night, consider provision of street lighting. • Enforce 'No Parking' on carriageway edge in multi-lane highways.

7.4.2 *Pedestrian Road Crashes*

Pedestrian crashes occur mainly due to vehicles hitting the pedestrians while (1) pedestrians walk along the road in direction of traffic or towards the traffic; (2) pedestrians crossing the road; (3) pedestrians standing on/by the road; and (4) pedestrians crossing the road and obscured by stopped / parked vehicle

Likely Contributory Factors	Possible Counter Measures	
• Lack of footway/footpath. • Available Footway/footpath in poor condition. • Footway/Footpath is obstructed with encroachments (temporary shops, parked vehicles). • Narrow road. • Poor visibility for pedestrians. • Poor visibility for drivers. • Wide carriageway to cross. • Excessive speeds • Heavy traffic volumes - few gaps in which to cross.	Improve facilities for pedestrians walking along the road Improve facilities for pedestrians crossing the road	• Provide raised footpaths, wherever possible. The kerb height shall not bemore than 150 mm high in raised footpaths. • Provide wide at-grade walkways on the edge of the carriageway[7] . • Consider providing Speed Tables at junction approaches in urban areas[8] . • Consider ribbed bar marking for edge line to discourage vehicles to encroach the shoulder portion of the road. • Provide controlled or uncontrolled pedestrian zebra crossing, as appropriate[9] . • Erect clearly visible advance warning signs for pedestrian crossings. • Construct pedestrian refuge (with barrier kerbs or with over-runnable kerbs) to enable pedestrians to cross wide roads in two stages.

[7] *All at-grade footpaths or walkways shall be paved with a different paving material, usually paving blocks or concrete; The choice of colour of paving blocks shall match with the surrounding nature of the environment–urban or rural*

[8] *Refer to IRC:99 for guidelines on provision of Speed Tables*

[9] *If the undivided carriageway width is more than 7m and the traffic on the road is high, providing a pedestrian holding area on the centre of the road (separating the opposite lanes) shall be considered, since crossing the road more than 7m in one go has been found to be unsafe for pedestrians; It is also not safer to provide uncontrolled zebra crossings on multi-lane high speed highways or multi-lane roads in urban areas, where pedestrian crossing volume is high; In such situations, either a signalized pedestrian crossing or grade separated crossings (FOB or Underpass) shall be considered;*

Likely Contributory Factors	Possible Counter Measures	
• No crossing facilities or clear places to cross. • Dark conditions – pedestrians not visible to the vehicular traffic. • Children playing in the road.	Speed limiting measures	• Construct Foot Over Bridge (FoB)[10] or Pedestrian subway[11], or PUP where this is justified by the volume of pedestrians and traffic. • If pedestrian crashes are occurring at a signal-controlled intersection, consider provision of pedestrian signals and an exclusive pedestrian phase.
	Improve visibility	• Speed limit signs. • Implement speed limiting measures. • Prohibit parking which obstructs visibility. • Removal of sight-limiting obstacles. • Where there is on-street parking, construct a build-out to improve visibility for pedestrians. • Consider street lighting (especially of crossing sites) if site is in an urban area. • Re-site bus stops so that buses do not obstruct visibility.

7.4.3 *Road Crashes between Vehicles Driving in the Same Direction (other than at Junctions)*

Crash Subtypes are:

a) Side swipe - changing lanes or collision while overtaking;

b) Hit from rear (nose-to-tail)

Likely Contributory Factors	Possible Counter Measures	
• Lack of lane markings • Lack of lane discipline • Confusion over which lane to be in • Lanes are too narrow	Improvement of road markings/ signs	• Provide lane markings and centerlines • Mark lane direction arrows where appropriate • Mark no-overtaking zones • Improve visibility, markings and signs in U-Turns

[10]*Where FOB is considered, the comfort and convenience of all users including senior citizens, women andpeople with disabilities has to be considered; FOB shall only be considered in urban areas and has to be provided with amenities such as lifts or ramps.*

[11]*Pedestrian subway shall only be provided where the environment is secure for women at all times of the day; The subway shall be well lighted and has to be kept well maintained at all times;*

Likely Contributory Factors	Possible Counter Measures	
• Dangerous overtaking • Careless driving - following too closely • Vehicle ahead stops suddenly (bus, taxi, auto) • Stopped vehicle sets off suddenly • Excessive speed • Dangerous U-turn • Contra flow: Wrong-way driving along a travel lane in a direction opposing the legal flow of traffic on a divided highway	Improvement of road markings/ signs	• Provide warning signs • Provide advance direction signs for junctions (consider overhead signs in multi-lane carriageways)
	Improvement of road facilities	• Provide extra widening on curves • Prohibit gaps in median to prevent hazardous U-turns • Provide bus bays where possible • To avoid contra flow, reposition median opening in the divided carriageway or provide service road upto the nearest safe crossing location to other carriageway
	Speed limiting measures	• Speed limit signs • Construction of speed limiting measures such as speed breakers or rumble strips • Active police enforcement

7.4.4 *Road Crashes at Junctions*

The subtypes of junctions crashes are:

a) Hit from side - vehicle from side road hits a vehicle on the main road
b) Hit from side - vehicle turning out of main road is hit by oncoming vehicle;
c) Hit from rear - vehicle going ahead or turning out of main road is hit by a following vehicle; and
d) Hit from side - vehicle in the roundabout is hit by an entering vehicle.

Likely Contributory Factors	Possible Counter Measures
"Hit from side" - vehicle from side road overshoots the stop/give way line and hits a vehicle on the main road	• If a cross-road, consider altering it to a staggered junction • If a skewed junction consider re-aligning the minor road so that it joins the major road at a right angle • Reshape the junction layout to include a right turn protected lane wherever possible with all safety elements • Ensure adequate warning signs/advance direction signs on the side road • Ensure there is a clearly visible Give Way or STOP sign • Install a splitter island in the side road • If a lot of the crashes are at night consider installing / improving street lighting • Consider installation of rumble strips or other traffic calming measures in the side road • If the junction is signal-controlled, improve the visibility of the signals (additional signal heads, overhead signals, backing boards). Consider provide vehicle actuated signal control. Moderate the cycle time according to the actual traffic volume

Likely Contributory Factors	Possible Counter Measures
"Hit from side" - vehicle from side road hits a vehicle on the main road after restarting from the stop / give way line	• Improve visibility at the stop/give way line by clearing obstructions • If a skew junction, consider re-aligning the minor road so that it joins the major road at a right angle • Consider installing traffic signals, if visibility cannot be improved • Consider installing traffic signals or roundabout if the volume of traffic warrants[12]
"Hit from side" - vehicle turning out of main road is hit by oncoming vehicle	• Clear any obstructions to visibility for vehicles waiting to turn right out of main road • Consider providing protected turning lane • If the junction is signal-controlled consider provision of a fully-controlled right turn phase
"Hit from rear" - vehicle going ahead is hit by a following vehicle	• Improve the warning signs/advance direction signs • If more rashes are observed due to wet weather , check skid resistance and drainage • At signal-controlled junctions check stopping sight distance to "tail of queue", and duration • on amber signal - improve the visibility of the signals and consider provision of overhead signals
"Hit from rear" - vehicle turning out of main road is hit by a following vehicle	• Improve the warning signs/advance direction signs • Provide protected right/left turn turning lane • Consider prohibiting the right turn if it can be catered for more safely at an another junction
"Hit from side" - vehicle in the roundabout is hit by an entering vehicle	• Improve the warning signs/advance direction signs • Provide Give Way signs and markings at the entries to the roundabout • Remove any obstructions to visibility close to the give way lines • Consider altering the geometry of the approaches arms so as to encourage slower speeds (increased deflection)
"Hit object on road" or "Ran off road" - vehicle entering the roundabout loses control	• Improve the warning signs/advance direction signs • Put Turn Left and Chevron signs on the centre island opposite each entry • Provide Give Way signs and markings at the entries to the roundabout • Consider altering the geometry of the approach arms so as to encourage slower speeds (increased deflection) • If there are a lot of wet weather crashes, check skid resistance and drainage • Consider installing rumble strips or other traffic calming measures on the approaches

[12]Refer IRC:65;

7.4.5 *Road Crashes between Vehicles Travelling in Opposite Directions on Undivided Roads*

The subtypes are:

a) Head-on collision while overtaking;

b) Other head-on-collisions

Likely Contributory Factors	**Possible Counter Measures**	
• Excessive speeds - loss of control • Inadequate overtaking sight distance • Short straight road section between consecutive curves • Steep gradient with slow heavy traffic • Slow traffic uses centre of road • Vehicles "cut the corner" at bends • Poor forward visibility • Vehicle swerves to avoid pothole • Vehicle swerves to avoid bad edge • No centerline • Narrow road	Improve control	• Mark no overtaking zones and consider installing no overtaking signs • Supplement markings with reflective studs • Use "ladder" hatch markings on centerline to create a painted median - and reinforce the markings with rumble strips • Install warning signs (e.g., for bends, junctions, narrow roads) • Install delineator posts on the centre line of sharp horizontal curves • Install speed limit signs and provide active police enforcement • If there is a median, consider: improving the signing/marking, widening of the median or provision of a median barrier • Providerumble strips/raised bar marking along the centre line
	Improve the road surface	• Patch potholes • Repair damaged edges
	Improve the alignment	• Improve sight distances by improving geometry or/and by clearing bushes or obstructions • Increase the number of sections with opportunity for safe overtaking • Construct overtaking/climbing lanes
	Upgrade the road	• Consider widening the lanes and/or shoulders (but note that excessive width might encourage dangerous overtaking) • Upgrade the road to a dual carriageway

7.4.6 *At-Grade Rail Road Crossing Crashes*

Likely Contributory Factors	Possible Counter Measures
• Excessive speed • Poor visibility • Careless overtaking • Inattention by driver • Failure of crossing control system • Crossing may be narrower than approach roads	• Install speed reducing measures (in the form of rumble strips, road humps, etc.) on the approaches. • Improve visibility of the crossing and light signals associated with it. • If the crossing is unmanned, improve the visibility along the rail track on the approach to the crossing. • Upgrade the signing and marking so that no-one can be in doubt that they are approaching a crossing - consider using "countdown posts". • Discourage overtaking by means of signs, markings or delineator posts. • Consider provision of street lighting. • Consult the railway authority about changing the control system (unmanned to manned or automatic). • Consult the railway authority about widening the crossing if it is narrower than the approach roads. • Consider replacing the crossing with an over bridge or under pass.

8. IMPLEMENTATION OF BLACKSPOT MITIGATION MEASURES

8.1 Introduction

The blackspot mitigation proposals depend on the complexity of the proposed mitigation measures. Road crash counter measures will only be successful if they are carefully designed with a lot of attention to site details. The formulation of mitigation scheme has benefits such as:

i. Enable safety engineer to check mitigation measures suitability at the site and there will not be any conflicts or other problems.
ii. Client will have better understanding of the mitigation proposals and subsequently make provision for budgeting, approvals, etc.
iii. Enable bidders to better understand and thus give a realistic quote.
iv. Provide a basis for controlling the construction work on site.

It is always good to discuss the proposed scheme with client, police and the people living and working around the site. Some safety awareness discussions shall be organized with road-users'regularly using the blackspot location (e.g. where pedestrians cross the road, or location of parked vehicles or vehicles passing through the location) in order to reduce road crashes. Without the support of local people, scheme might fail and the signs and other road furniture may be vandalized or stolen.

8.2 Blackspot Mitigation Measures

The blackspot safety measures shall be detailed as short term and long term. The short terms measures can be descriptive giving details of the existing road features and mitigation measures along with a sketch or site layout of the location. The long term measures shall be described

along with the base map of blackspot location. A base map shall be prepared giving details of road geometry, cross sections, roadside features, intersections, etc. The mitigation measures shall be superimposed on the base map.

The existing layout of the blackspot with the features shall be shown as "Existing Scenario" against which blackspot improvement measures shall be shown as "Proposed Blackspot Mitigation Measure" for the Client and Execution Agencies to appreciate all the improvement proposals. This would also ensure the implementation of all improvement measures as envisaged by the Safety Engineer, lest perhaps some measures could be neglected by the Contractor. The layouts and provision of relevant IRC codes and Manuals should be indicated in the improvement proposals.

8.3 Detailed Design of Blackspot Mitigation Measures

In case of high cost long term measures being preferred to address a crash prone location instead of low cost measures, it is essential that a detailed design of the mitigation measures shall be undertaken before its implementation so as to achieve its effectiveness.The detailed design report shall be prepared carrying out all field investigations and design as these are being done in the case of upgradation of an existing road. The detailed design may involve topographic surveys, traffic studies, soil and geotechnical surveys, geometric design, structural design, intersection designs, road signs, road delineators and pavement marking proposals, estimation of quantities and costing, cost benefit analysis and preparation of bid documents.

8.4 Implementation

The mitigation measures can be implemented as part of the routine maintenance in case of short term measures or as an independent work for long term measures.

8.5 Site Trial

A virtual/site trial of the mitigation scheme on intersections can give an idea about its effectiveness. It is particularly appropriate for urban schemes where new features are introduced (e.g. splitter islands, refuge island) on the road. It also gives an opportunity to test the scheme in association/ consultation with the Police and key stakeholders. Incase of site trial, the simplest way is to mark out the new kerb lines and islands with traffic cones and, if possible, install temporary traffic signs. Then the road users behavior can be observed with the new layout.

8.6 Work-Site Safety during Implementation

The blackspot improvement scheme must set a good example to ensure safety at road works during implementation of mitigation measures. The work zone safety measures shall be provided as per relevant IRC provisions.

8.7 Scheme Implementation Record

A detailed implementation record is required to be maintained to evaluate the effectiveness of a scheme. The implementation record shall have site investigation report, crash details, as built drawings and actual cost of implementation.

8.8 Public Awareness Campaign

When the scheme requires road users to alter their usual behavior, it is advisable to conduct a public awareness campaign. This is particularly important if the scheme is restrictive in nature such as closing of median opening/restriction on the movement of certain vehicle types, change of layout of a junction etc.

9. MONITORING AND EVALUATION

9.1 Introduction

Proper monitoring and evaluation of a set of road safety interventions is of fundamental importance. Much of the counter measures implemented at a site could be new and untried in the Indian context, even though these are proven to be effective elsewhere. It is also possible that some of the interventions are new, quite expensive, and/or their effectiveness were not well documented before. Only by monitoring its performance closely will enable to learn what is cost-effective - and such information will help gradually build up a sound basis for road safety engineering in a region. Evaluation is not easy and it will rarely be possible to obtain 100% clear proof that particular measures have prevented crashes, but it can give indications about improvements which are helpful as counter measures in specific types of crashes. In addition to measuring cost-effectiveness, safety engineering team should be looking for any unintended effects (on road user behaviour, traffic patterns, etc.) and should try to gauge public acceptability of the safety engineering measures. The scheme needs to be soundly-based to learn anything useful from it - this means that there must have been a clear statement of the objectives of the scheme, in terms of crashes it targeted, prediction of its effects and a logical link between the treatment and its effects.

9.2 Initial Observations

It is advisable to monitor the scheme particularly closely in the first few days and weeks after implementation. It is expected that road users will take some time to get used to new traffic schemes and junction improvements, and a few crashes may happen during this time.The team should be ready to review the scheme and alter it if there is evidence of serious problems. Schemes may work well for reduction of target crashes, but may not be responsive to other random crashes, and in such cases evaluating whether the costs are beginning to exceed the benefits should be carefully judged. In other words, it is important to highlight that a set of interventions would target only certain specific types of crashes, and not all crashes. In such times, there may be public criticism of the scheme and the team should be prepared to respond promptly to this - by explaining what has been done and why, and showing that the team is taking a responsible attitude to any problems that are occurring.

9.3 "Before" and "After" Studies

The basic method of measuring the effect of a scheme is to compare the situation before it was implemented with that after it was implemented. It seems simple, but there are some complications, including the need to make allowance for:

- extraneous factors (e.g. changes in weather, traffic patterns, vehicle mix, traffic rules) which could account for some or all of the change that has been observed
- the fact that crashes are to some extent random, which adds extra variability into the crash data, thus making the effects of the scheme more difficult to detect in the short term
- the likelihood that for a site chosen on the basis of the high reported number of crashes, there would be a reduction in crashes over time regardless of whether anything was done (called the regression to the mean effect)
- the likelihood that implementation of a scheme (construction) will disturb the traffic situation for a little while - for this reason, data on the traffic and crash situation during and immediately after the construction period is usually ignored.

9.4 Short-Term Measures of Performance

The most important measure of success is whether the scheme has improved the crash situation at the site which can be established only through a statistical analysis. However it takes 2-3 years to build up the data necessary for a proper statistical analysis and it is often required to make some assessment of scheme performance before that. In most cases there are other variables which when measured "before" and "after" will give an indication of whether safety at the site has improved. Examples include:

- traffic speeds - many schemes aim to improve safety through reducing traffic speeds, so speed surveys will tell you whether the targeted speed reduction or speed compliance has occurred
- conflicts - a "before" and "after" conflict study can show whether the conflicts that were causing the problem have reduced
- the number of pedestrians using crossings - a simple count can show whether measures to promote the use of crossings (better signing, refuges, etc) has increased usage
- road user perception - it can sometimes be useful to interview road users to see whether they think the road is now easier and safer to use

9.5 Statistical Tests

There are a number of statistical tests for comparing the safety performance at a site before and after a scheme has been implemented, but the most commonly-used are:

- Tanner k test
- Chi-squared test

Both these tests involve comparing before and after data from the treated site with before and after data from similar but untreated sites, known as control sites.

9.5.1 *Before and After Periods*

These must be long enough to even out the random variations in crash frequency, and it is generally assumed that 3-year period is enough (i.e. three years before and three years after). The test can be used with less data, but the margins of error are larger. The periods must be the

same for both the treated site and the control sites.

9.5.2 *Choosing Control Sites*

The purpose of comparing the treated site with the control sites is to take account of the extraneous factors such as weather and traffic flow changes which may be causing an area-wide change in the crash situation. The best control sites are those which are similar to the treated site and in the same area - in this way one can be sure that both sites have been similarly affected by local variation in extraneous factors. In practice this is difficult, especially as one need enough control sites to give about ten times as many crashes as at the treated site(s). One may have to take control data from a wider area, but it is critical to ensure that the sites are broadly similar to the treated site.

9.5.3 *Correcting for the Regression to the Mean Effect*

To eliminate the effect of "bias by selection" by choosing sites on the basis of having a very high number of crashes in the previous one or two years, certain corrections need to be applied. As crashes are random events, crash rates at individual sites vary from year to year. So, if a site chosen when the crash rate is at its peak, the crashes in subsequent years will tend to reduce even if no treatment is applied. Statisticians call this "regression to the mean". There is less likelihood of bias if longer periods of time are selected for study. However, in case the crash data is not spread over sufficient time, it is recommended that one makes allowance for regression to mean by applying the factors set out in the following **Table 9.1,** which are based on studies in Britain.

Table 9.1 Factors to be used to allow for "Regression to the Mean"

Period of Data Considered for Crash	Regression-to-Mean Change in Annual Crash Rate
One year	15 to 26 per cent
Two years	7 to 15 per cent
Three years	5 to 11 per cent

Source: Abbess, Jarrett, and Wright,1981, Accidents at blackspots: estimating the effectiveness of remedial treatment, with special reference to the "regression-to-mean" effect, Traffic Engineering and Control.

Note: To correct for the regression to the mean effect you would reduce the "before" crash total for the site by 5 to 11% and then calculate the k value and the Chi-squared value.

9.5.4 *Worked Example of the Tanner k Test*

Traffic calming was done three years ago on a busy national highway passing through a hamlet development. The effect of the scheme on crashes needs to be checked. The control data is from other villages on busy main roads over exactly the same 3-year before and 3-year after period. The crash data for the above corridor is arranged as shown in **Table 9.2:**

Table 9.2 Total Number of Crashes: Before and After Implementation

Crashes at site		Crashes at control sites	Total
Before	10 (a)	75 (c)	85 (g)
After	2 (b)	66 (d)	68 (h)
Total	12 (e)	141 (f)	153 (n)

The data is then entered into the formula given in Equation 9.1:

$$k = \frac{b/a}{d/c} k = \frac{b/a}{d/c}$$ Equation 9.1

Note: if any of the frequencies are zero, then 1/2 should be added to each, i.e.

$$k = \frac{(b+\frac{1}{2})/(a+\frac{1}{2})}{(d+\frac{1}{2})/(c+\frac{1}{2})} k = \frac{(b+\frac{1}{2})/(a+\frac{1}{2})}{(d+\frac{1}{2})/(c+\frac{1}{2})}$$ Equation 9.2

This gives:

k = (2/10)/(66/75) = 0.227

if k < 1 then there has been a decrease in crashes relative to the control, if k = 1 then there has been no change relative to the control, if k > 1 then there has been an increase relative to the control

The percentage change at the site is given by:

(k-1) x 100% Equation 9.3

As k<1 there has been a decrease in crashes relative to the controls of: (0.227 - 1) x 100% = 77.3 %

Based on the above results, it is evident that real change in crashes has taken place at the site due to the implementation of the intervention.

9.5.5 *Worked Example of the Chi-Squared Test*

This test indicates whether there is a significant difference between the site data and the control data. Consider the same example as used above. The formula proposed in Equation 9.4 is used:

$$\chi^2 = \frac{\left(|ad - bc| - \frac{n}{2}\right) 2\,n}{efgh}$$ Equation 9.4

This gives:

$((|10x66 - 2x75| - (153/2))^2 \times 153)/(12x141x85x68)$

$\chi^2 = 2.939$

The result can be interpreted by using **Table 9.3.**

Table 9.3 Understanding Significance of Chi Square Ranges

Chi square value	Significance level	Confidence level	Interpretation
>2.71	10%	90%	Fair
>3.84	5%	95%	Acceptable
>6.635	1%	99%	Highly acceptable

A close look at the estimated value of x^2 and its comparison with tabulated values of 9.3 revealed that there is less than a 10% likelihood that the change in crashes at the treated site is due to random fluctuations. This implies that there is more than 90% probability that a real change in crashes has taken place at the site due to the implementation of the intervention.

9.5.6 *Interpretation of the Results*

The above tests tell you nothing about how the change in crashes came about. So before you use the relevant test result to demonstrate how well your scheme has worked, it is important to check that the crash data supports your case. Usually your scheme will have targeted a particular type (or types) of road crashes, so check (by repeating the collision diagram) whether the intended type of road crash has in fact decreased. And ask yourself whether there is any other plausible reason why the crashes may have decreased at the site. Once you have discounted any other possibility you are left with the probability that the decrease in crashes has come about as a result of your improvement scheme.

9.6 Assessing the Benefit Cost of Counter Measures After Implementation

After implementing the scheme, it is worth calculating the First Year Rate of Return (FIRR) based on actual crash data after implementation with a view to develop the Benefit-Cost Ratio (BCR) and to assess the Cost –Effectiveness of each countermeasure. The above analysis would help to demonstrate that the implementation of blackspot mitigation measures gives good value for money.

Definitions for Treating Blackspots in various Countries

Country	Reference to Population of Sites	Sliding Window Applied	Reference to Normal Level of Safety	Recorded or Expected Number of Accidents	Crash Severity Considered	Length of Crash Period
Australia	No	Yes, 250 m	Yes, by means of critical values for accident rate	Recorded minimum critical value 3 – function of traffic volume	No	3 years
Denmark	Yes detailed categorization of roadway elements	Yes for road sections – variable length	Yes – by means of accident prediction models	Recorded based on statistical tests – minimum 4 accidents	No	5 years
Flanders	No	Yes 100 m	No	Recorded weighted by severity	Yes by means of weights	3 years
Germany	No	No, accident maps inspected	No	Recorded minimum values 3 or 5	Yes by different critical values	1 year (all accidents), or 3 years (injury accidents)
Hungary	No	Yes 100 m or 1000 m	No	Recorded minimum 4	No	3 years
Norway	Not when identifying black spots	Yes 100 m (spot), 1000 m (section)	Yes by means of normal accident rates for roadway elements	Recorded higher than normal by statistical test minimum values 4 (spots) or 10 (sections)	Yes by estimating accident costs and potential savings	5 years
Portugal	Two definitions are used for black spots, Yes for one definition, no for other	Two definitions are used for black spots, Yes for one definition, no for other	Two definitions are used for black spots, Yes for one definition, no for other	Recorded in one definition (minimum 5) expected in other	Two definitions are used for black spots, Yes in one definition (by severity weighting), no in other	1 year or 5 years

Definitions for Treating Blackspots in various Countries

Country	Reference to population of sites	Sliding Window applied	Reference to normal level of safety	Recorded or expected number of accidents	Crash Severity Considered	Length of Crash Period
Switzerland	Yes open roads and junctions	No , fixed section of variable length	Yes	Recorded a set of critical values	Yes by different critical values	2 years
PIARC	Yes	No, map based clustering approach	Yes by means of critical values for road sections and junctions	Recorded based on threshold value of 5 crashes per year or 3 pedestrian injuries per year	Yes selection is recommended based on accident severity	3-5 years
South Africa	Yes	Area or Region wise window (30-50m radius) applied in absence of data Precise location using maps or GPS in presence of data	Yes by means of crash density (number of accidents divided by length of road)	Recorded based on indices if data is available	Yes	3 -5 years
Turkey	Yes	No, fixed section of 1 km length	Yes by means of critical values of frequency, severity and rate	Recorded, indices exceeding the critical values	Yes	3 years
HSM 2010	Yes	No, aggregation based on base conditions	Yes by means of accident prediction models called Safety Performance Functions	Recorded based on weighed observed and predicted values using Empirical Bayes Method	Yes in some cases	3 years

Definitions for Treating Blackspots in various Countries

Country	Reference to population of sites	Sliding Window applied	Reference to normal level of safety	Recorded or expected number of accidents	Crash Severity Considered	Length of Crash Period
UK	Yes	No	Yes based on authorities own average accident rates or regional average accident rates and national average rates	Recorded, based on STATS 19 database	No	3 years
Indonesia	Yes	No, a fixed length of 500 m for road segment and a distance of 100m from intersection	No, based only on weighed severity index	Recorded	Yes	2 years

Annexure B

Average Annual Total Crashes (AATC)

STATE/UT	AATC/KM			3AATC/500m			5AATC/500m			10AATC/500m			15AATC/500M		
	NH	SH	ODR	NH	SH	ODR	NH	SH	ODR	NH	SH	ODR	NH	SH	ODR
Andaman and Nicobar Islands	0.25	0.21	0.64	0.37	0.32	0.96	0.61	0.53	1.61	1.23	1.07	3.21	1.84	1.60	4.82
Andhra Pradesh	1.28	0.91	0.31	1.92	1.36	0.46	3.20	2.27	0.76	6.40	4.55	1.53	9.60	6.82	2.29
Arunachal Pradesh	0.04	0.01	0.02	0.05	0.01	0.02	0.09	0.02	0.04	0.18	0.05	0.08	0.27	0.07	0.12
Assam	0.93	0.75	0.49	1.39	1.13	0.73	2.32	1.89	1.22	4.65	3.77	2.44	6.97	5.66	3.66
Bihar	0.76	0.56	0.26	1.14	0.85	0.40	1.90	1.41	0.66	3.80	2.82	1.32	5.70	4.23	1.99
Chandigarh	2.80	0.00	3.86	4.20	0.00	5.78	7.00	0.00	9.64	14.00	0.00	19.28	21.00	0.00	28.92
Chhattisgarh	1.21	0.73	0.56	1.82	1.09	0.84	3.03	1.82	1.40	6.05	3.63	2.81	9.08	5.45	4.21
Dadra and Nagar Haweli	0.00	0.37	0.32	0.00	0.55	0.48	0.00	0.92	0.81	0.00	1.83	1.61	0.00	2.75	2.42
Daman and Diu	0.14	0.09	0.71	0.20	0.14	1.07	0.34	0.23	1.78	0.68	0.45	3.55	1.02	0.68	5.33
Delhi	25.99	0.00	2.48	38.98	0.00	3.72	64.97	0.00	6.19	129.94	0.00	12.39	194.91	0.00	18.58
Goa	5.49	1.45	1.81	8.24	2.18	2.72	13.73	3.63	4.53	27.46	7.25	9.07	41.19	10.88	13.60
Gujarat	0.86	0.32	0.33	1.29	0.49	0.49	2.15	0.81	0.81	4.30	1.62	1.63	6.45	2.43	2.44
Haryana	1.52	1.67	0.19	2.28	2.50	0.29	3.80	4.17	0.48	7.60	8.34	0.97	11.40	12.51	1.45
Himachal Pradesh	0.55	0.91	0.32	0.83	1.36	0.49	1.38	2.26	0.81	2.77	4.53	1.62	4.15	6.79	2.43
Jammu and Kashmir	0.82	4.88	0.26	1.23	7.32	0.39	2.04	12.20	0.65	4.09	24.40	1.30	6.13	36.60	1.96
Jharkhand	0.68	1.26	0.18	1.01	1.89	0.27	1.69	3.15	0.45	3.38	6.31	0.90	5.07	9.46	1.36
Karnataka	2.11	0.57	0.35	3.16	0.85	0.53	5.27	1.42	0.88	10.55	2.84	1.75	15.82	4.26	2.63
Kerala	5.04	1.67	0.84	7.55	2.50	1.26	12.59	4.17	2.09	25.18	8.34	4.18	37.77	12.51	6.28
Lakshadweep	n.a	n.a	0.01	n.a	n.a	0.01	n.a	0.00	0.02	n.a	n.a	0.04	n.a	na	0.06
Madhya Pradesh	1.35	1.25	0.70	2.03	1.88	1.05	3.38	3.13	1.74	6.75	6.25	3.48	10.13	9.38	5.23
Maharashtra	0.63	0.22	0.17	0.94	0.32	0.26	1.56	0.54	0.44	3.13	1.08	0.87	4.69	1.62	1.31
Manipur	0.20	0.22	0.01	0.29	0.33	0.01	0.49	0.54	0.02	0.98	1.09	0.04	1.47	1.63	0.06
Meghalaya	0.22	0.13	0.04	0.33	0.20	0.06	0.55	0.34	0.10	1.10	0.67	0.19	1.65	1.01	0.29
Mizoram	0.03	0.11	0.01	0.04	0.16	0.01	0.06	0.26	0.02	0.13	0.53	0.04	0.19	0.79	0.06
Nagaland	0.18	0.11	0.01	0.27	0.16	0.01	0.46	0.27	0.02	0.91	0.53	0.04	1.37	0.80	0.06
Odisha	0.89	0.80	0.20	1.33	1.19	0.30	2.22	1.99	0.51	4.45	3.98	1.01	6.67	5.97	1.52
Pondicherry	13.45	0.00	1.52	20.17	0.00	2.28	33.62	0.00	3.80	67.24	0.00	7.59	100.86	0.00	11.39
Punjab	0.90	1.69	0.32	1.35	2.53	0.47	2.25	4.21	0.79	4.50	8.43	1.58	6.74	12.64	2.37

Average Annual Total Crashes (AATC)

STATE/UT	AATC/KM			3AATC/500m			5AATC/500m			10AATC/500m			15AATC/500M		
	NH	SH	ODR	NH	SH	ODR	NH	SH	ODR	NH	SH	ODR	NH	SH	ODR
Rajasthan	0.85	0.23	0.51	1.27	0.35	0.77	2.12	0.59	1.29	4.25	1.17	2.57	6.37	1.76	3.86
Sikkim	0.17	0.10	0.03	0.26	0.15	0.05	0.43	0.26	0.09	0.85	0.51	0.17	1.28	0.77	0.26
Tamil Nadu	4.24	1.90	0.51	6.35	2.84	0.76	10.59	4.74	1.27	21.18	9.48	2.54	31.77	14.22	3.82
Telangana	1.82	1.50	0.56	2.73	2.25	0.83	4.55	3.76	1.39	9.10	7.51	2.78	13.65	11.27	4.16
Tripura	0.25	0.59	0.12	0.38	0.89	0.17	0.63	1.48	0.29	1.27	2.97	0.58	1.90	4.45	0.87
Uttar Pradesh	1.67	1.71	0.22	2.50	2.57	0.33	4.17	4.29	0.55	8.34	8.57	1.10	12.51	12.86	1.65
Uttarakhand	0.32	0.10	0.06	0.47	0.14	0.09	0.79	0.24	0.14	1.58	0.48	0.29	2.36	0.72	0.43
West Bengal	1.43	0.89	0.53	2.15	1.34	0.79	3.58	2.23	1.32	7.16	4.45	2.63	10.74	6.68	3.95

Annexure C

List of Attributes for Crash Data Collection and Analysis

Attributes	Analysis Types
• Total number of crashes observed in a state • The length of national highways, state highways and Major District roads within a state	• Black Spot Identification and Prioritization using Average Annual Total Crashes
• Crash Type i. Fatal: ii. Grievous iii. Minor iv. No injury. • Number of Persons i. Number of persons killed ii. Number of persons grievously injured. iii. Number of persons with minor injury. • Number of Motorized/Non-motorised Vehicles Involved i. Number of Motorised Vehicles ii. Number of Non-Motorised Vehicles iii. Number of Pedestrians Involved • Weather: Weather denotes the climatic conditions at the time of road crash. Only one weather condition should be marked. i. Sunny: ii. Rainy: iii. Foggy/Misty iv. Hail/Sleet	
• Type of Collision A. Collision of: This describes the nature of collision for e.g. Vehicle – Vehicle, Vehicle – Pedestrian, etc. Mark all appropriate options. Multiple options may be checked if required. B. Collision With: This describes the type of Collision. i. Parked Vehicle: If the collision involves a parked vehicle. ii. Hit from Back: If one of the vehicle involved in the road crash is hit from back. iii. Hit from side: If the crash is either a side swipe crash or a right angle crash. iv. Run off-Road: If the vehicle leaves the carriageway or runs off road. v. Overturned: If any of the vehicles involved in the crash has overturned. vi. Hit Stationary Object: If the crash involves only one vehicle which collided with a fixed object. vii. Head on Collision: If the front end of two vehicles hit each other in opposite direction. viii. Others: All others cases. • Name of the Road. • Landmark • Chainage • No. of Lanes i. 2 lanes or less ii. More than 2 lanes. All highways with divided carriageway falls under this category.	• Black Spot Identification and Prioritization using Cluster analysis • Heat maps • Hotspot

Attributes	Analysis Types
• Road Surface i. Paved. ii. Unpaved. • Road Type: Road Type describes the category of the road. Check the appropriate road type. • Physical Divider: Yes. No. • Crash Prone Spot: Crash Spot denotes the type of predominant human activity. Only one blackspot should be marked. i. Residential ii. Institutional iii. Market/Commercial iv. Open v. Others • Road Features A. Features: Check if the road is straight or curved at the location of crashes. B. Features: Check if the road has a bridge or culvert at the location of crash. C. Features: Check if potholes are present on the road at the location of crash. D. Features: Check if the location of crash is at a steep gradient (uphill/downhill, ramps, etc.). • Road Junction: Check the appropriate junction type if the crash occurred at a junction. • Type of Traffic Control (if crash is at a junction): Check the appropriate type of traffic control at the location of crash. • Pedestrian Infrastructure: Check the appropriate type of pedestrian infrastructure at the location of crash If there are no pedestrian infrastructure provided, mark None.	
• Crash Type i. Fatal: A road crash in which one or more persons are killed. ii. Grievous (Hospitalized): A road crash in which none of the victims are killed however at least one person has sustained one or more serious injuries such as fractures, internal body injury, severe general shock, unconsciousness and needs hospitalization for medical treatment. iii. Minor (Not Hospitalized): A road crash in which none of the victims were killed nor were any victim hospitalized. However, at least one of the victims has slight injury and requires first aid. iv. No injury: A road crash in which none were harmed in any way and does not even require a first aid. However, public or private property may have been damaged and requires restoration which includes the vehicle damages as well.	• Severity weighting

Source:MoRTH
https://morth.nic.in/sites/default/files/ASI/Revised_Road_Accidents_Data_Recording_and_Reporting_Formats.pdf date accessed : 19 June 2020

Annexure D

Physical Checklist for Site Investigation

Site Reference: .....

State....., District .....

Road No. .....Chainage (from/to) :.....

Location description: .....

Police Station: .....

Landmarks .....

Blackspot ID: (if available): .....

GPS Coordinate (Latitude/Longitude): (if available): .....

Blackspot Type: (Junction/mid-block/median opening/structure)

Were accidents caused by the physical condition of the road, such as sight obstructions, blind corners, wrongly-sited islands, road signs, or adjacent property? Can the physical conditions leading to the accidents be corrected?

1. Is the first principles for a priority junction or for a roundabout or for signal controlled junction is catered in the layout design?
2. Is both vertical and horizontal alignment adequate in respect of broken back curves and for change of grade in vertical alignment?
3. Is the visibility funnel encumbrance free?
4. Are lane widths adequate? (turning lanes: minimum 3.0 m; other lanes: minimum 3.25 m)
5. Are there adequate facilities for pedestrians?
6. Should pedestrian crossings be relocated/repainted?
7. Are the road signs adequate in terms of their message, size, placement, or conformity to specification of materials used?
8. Are the signals adequate in terms of their placement, conformity, number of signal heads, or timing?
9. Are road markings adequate in terms of type, clarity and location?
10. Is traffic properly channelized to minimize the occurrence of accidents?
11. If night-time accidents represent a considerable proportion of the total number of accidents, is the street lighting or the number of reflectors adequate?
12. Are parking arrangements adequate?
13. Are the bus stops located in a safe place?
14. Does the road geometry encourage safe speeds?
15. Is the road surface adequate? Does it drain properly?
16. Are there obstructions in the road or close to the edge?
17. In bridge approach is provided with adequate marking to make the vehicle to align well ahead in the approach itself within the available carriageway width of the bridge

Comments:

Annexure E

Operational Checklist for Site Investigation

Site Reference: .....

State....., District.....

Road No. .....Chainage (from/to) :.....

Location description: .....

Police Station: .....

Landmarks .....

Blackspot ID: (if available): .....

GPS Coordinate (Latitude/Longitude): (if available): .....

Blackspot Type: (Junction/mid-block/median opening/structure)

1. Is the driver's view of other vehicles/pedestrians obstructed?
2. Do drivers respond incorrectly to signals, signs, or other control devices?
3. Do drivers have trouble understanding and finding the correct path through the location?
4. Are there hidden hazards - such as a sharp bend beyond a crest?
5. Are there hazards that vehicle approaching junction cannot see each other?
6. Are vehicle speeds excessive for this situation? Are there speed differences? If yes, in which driving direction?
7. Are parking or other traffic regulations regularly violated?
8. Are vehicles delayed? Can the delays be reduced?
9. Are there traffic flow deficiencies or traffic conflict patterns associated with turning movements?
10. Would one-way operation make the location safer?
11. Is the traffic volume causing problems? Are there sufficient gaps in the main road traffic to enable drivers from side roads to enter the main road without excessive delay?
12. Are there sufficient gaps in the traffic to enable pedestrians to cross the road without excessive delay?
13. Are pedestrians crossing the road at the safest places? Can they see whether it is safe to cross?
14. Is there need for effective/selective enforcement or effective/selective maintenance?
15. Are buses and bus passengers using the facilities that have been provided for them?

Comments:

(The Official amendments to this document would be published by the IRC in its periodical, 'Indian Highways' which shall be considered as effective and as part of the Code/Guidelines/Manual, etc. from the date specified therein)

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